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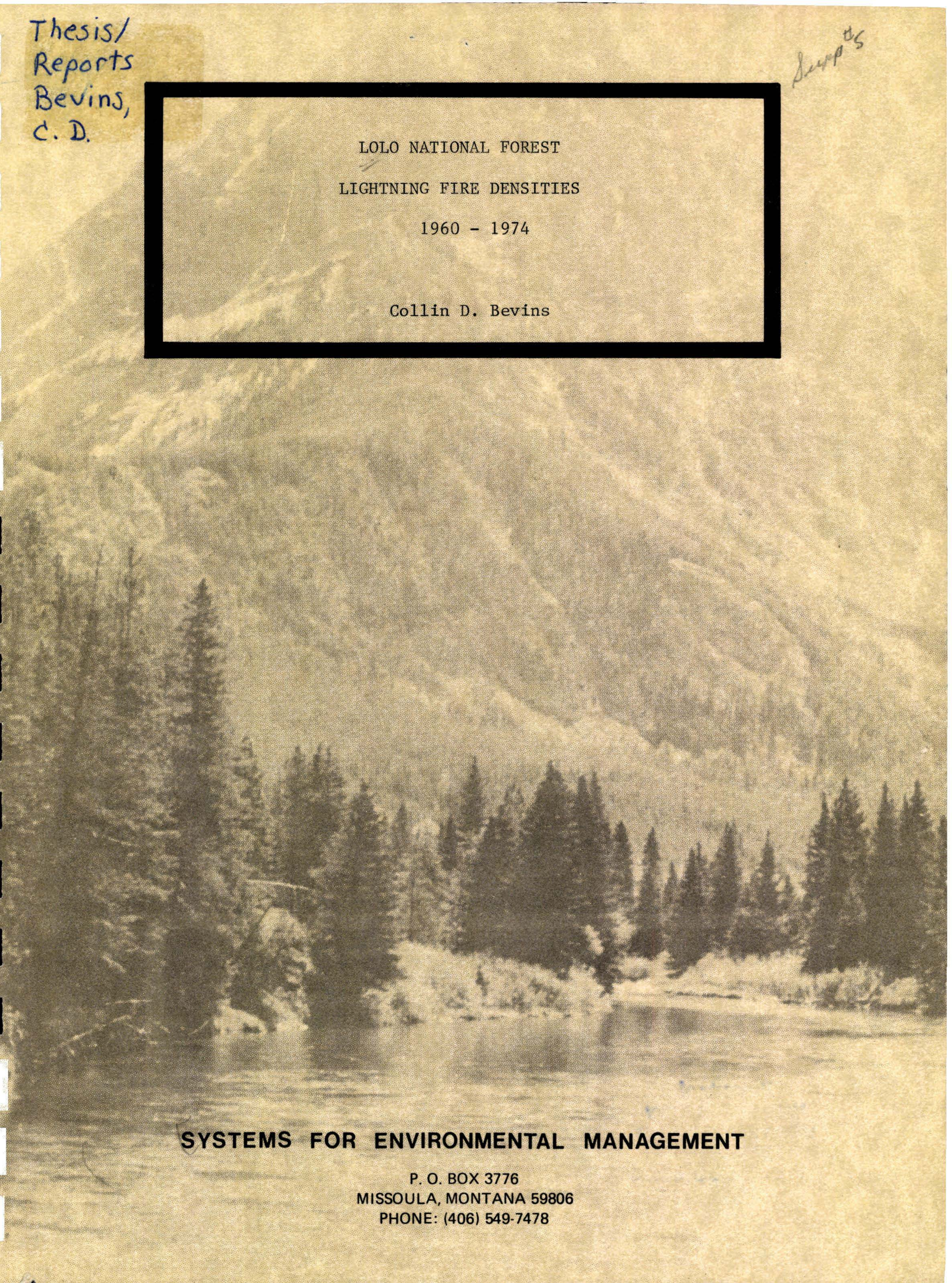
LOLO NATIONAL FOREST
LIGHTNING FIRE DENSITIES
1960 - 1974

Collin D. Bevins



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LOLO NATIONAL FOREST

LIGHTNING FIRE DENSITIES

(1960 - 1974)

by

Collin D. Bevins
Research Coordinator

Systems for Environmental Management
P.O. Box 3776
Missoula, Montana 59806

April 1979

The study presented was conducted as part of a Cooperative Aid Agreement between Systems for Environmental Management, Missoula, Montana, and the Fire in Multiple Use Management RD&A Program, Intermountain Forest & Range Experiment Station, Northern Forest Fire Laboratory, Missoula, Montana.

Submitted by : ______________________________ Date __________
Collin D. Bevins, Research Coordinator
Systems for Environmental Management

Recommended by : ______________________________ Date __________
Dr. Richard J. Barney, Research Forester
Fire in Multiple Use Management RD&A Program

Approved by : ______________________________ Date __________
Dr. James E. Lotan, Program Manager
Fire in Multiple Use Management RD&A Program

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Introduction to Forest Fire Density

Mean annual lightning fire statistics for the Lolo National Forest are presented in this paper for the fifteen year period from 1960 through 1974. The fire statistics presented are:

- lightning fire occurrence (fires/year),
- lightning fire occurrence density (fires/million acres/year),
- lightning fire acres burned (acres burned/year),
- lightning fire acres burned density (acres burned/million acres/year),
- mean lightning fire size (acres), and
- median lightning fire size (acres).

The lightning fire statistics are reported for classes within five common forest and site stratifications:

- dominant forest cover type (by plurality),
- stand management status,
- elevation band (msl),
- aspect class, and
- slope steepness (percent).

Forest fire occurrence, as used in this report, is the absolute number of fires occurring within a forest or site class during the fire season. Forest Service administered nonwilderness lands on the Lolo National Forest, for example, had 1241 lightning fires reported from 1960 through 1974, for a mean annual lightning fire occurrence of 82.7 fires per year.

Forest fire occurrence has been the traditional fire statistic available to, and used by, fire planning and management personnel. Yearly summaries of fire occurrence such as the Northern Region's Annual Regional Fire Report have been produced from each year's accumulation of Individual Fire Report (5100-29) forms. The annual reports, prepared by the Fire and Aviation Management Office, concentrates largely on fire occurrence within established administrative boundaries, and on the types and extent of suppression forces deployed. Fire occurrence summaries have also been prepared by Barrows (1951) and Barrows, Sandberg, and Hart[1] addressing fire occurrence by geographic location, forest cover type, elevation band, and aspect and slope class.

The major limitation in using historical fire occurrence for planning purposes is the absence of information on the corresponding acreages over which the fires occurred. The problem is trivial for fire occurrence within administrative boundaries where acreages are well known. However, acreage estimates have not been readily available for forest cover type and site classes, making flammability (risk and hazard) assessment and comparisons between classes, at best, an educated guess. Such assessment can be made only when fire occurrence per unit area and time, or fire density, is known.

Forest fire occurrence density is the forest fire occurrence within a forest or site class normalized by the class's acreage during the fire season. The 1241 lightning fires on the Lolo National Forest occurred over an estimated land area of 1,978,373 acres[2], for a fifteen year lightning fire occurrence density of 41.8 fires per million acres per year.

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[1] Lightning Fires in the Northern Rocky Mountain Forests. Unpublished final report to USDA Forest Service Intermountain Forest & Range Experiment Station, Northern Forest Fire Laboratory, Fire Meteorology Project, Missoula, Montana. April 1977. 182 pages.

The fire occurrence density statistic has a potentially broader application to fire planning and analysis than does the raw fire occurrence number. Use of the density estimate enables direct comparison of fire occurrence and flammability between classes within a forest or site stratification (e.g., between ponderosa pine and Douglas-fir cover types), as well as between classes of different stratifications (e.g., which is more flammable, ponderosa pine on all aspects, or south-southwest aspects of all cover types?). The fire occurrence density statistic flags those classes of greatest risk and flammability which may be of special interest in fuels management and fire and forest planning.

The fire occurrence density may also be interpreted as a fire probability estimate. Under the assumption that lightning fires strike randomly throughout the Lolo National Forest, the probability of a lightning fire starting on any particular forest acre during a single fire season is estimated as

$$41.8 \text{ fires/million acres/year} \times 10^{-6} = 4.18 \times 10^{-5}.$$

The acres burned fire statistic is the absolute number of acres burned within a forest or site class during the fire season. Forest Service administered nonwilderness lands on the Lolo National Forest averaged 328.3 acres burned annually by lightning fires from 1960 through 1974.

The acres burned density is the absolute number of acres burned within a forest or site class normalized by the class's acreage during the fire season. Again, for Forest Service administered nonwilderness lands within the Lolo National Forest, the mean annual lightning fire acres burned density from

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[2] Forest acreage estimates from 1974 Stage 1 inventory as computed by USDA Forest Service's FINSYS subsystem routines TABLES and OUTPUT.

1960 through 1974 was 165.9 acres burned per million acres per year.

Perhaps the most useful interpretation of the acres burned density is as an expression of the mean percent of land area burned annually. The mean acres burned density of 165.9 indicates 0.01659% of the Lolo National Forest was burned per annum from 1960 through 1974. Similarly, there was a yearly probability of 1.659×10^{-4} that any given forest acre would burn during the fire season. The inverse of the annual probability of a single acre burning may furthermore be used as an approximation to the fire periodicity, burning cycle, or "burnover" rate for the forest. Under the assumption that lightning fires are randomly distributed throughout the Lolo National Forest, the mean burnover rate from 1960 through 1974 was 6028 years. That is, it will theoretically take 6028 years for the Lolo National Forest to burn over completely one time under the 1960 through 1974 fire occurrence and suppression regime. As will become evident in the remainder of the report, lightning fires do not occur or burn randomly or uniformly throughout the Lolo National Forest but vary significantly between forest and site stratification classes.

Finally, mean and median fire size is presented for all lightning fires in each forest and site class during the fifteen year period studied. Since over 80% of all lightning fires on the Lolo National Forest were under one acre in size, an order of magnitude difference often exists between mean and median fire sizes for a forest or site class. The mean fire size statistic is more strongly influenced by occasional, large conflagrations than is the median, and the mean is therefore generally larger than the median. The fifteen year mean lightning fire size on the Lolo National Forest was 4.0 acres. The median fire size was 0.2 acres; at least half of all lightning fires were under 0.2 acres in size.

Study Methods

Individual Fire Report (5100-29) forms from 1960 through 1974 were accessed to determine absolute fire occurrence and size by cover type, stand management status, elevation, aspect, slope steepness, and slope position for the Lolo National Forest. A total of 2711 fires from all causes were reported during the fifteen year period studied, of which 1805 (67%) were lightning-caused and 905 (33%) were man-caused. Lightning fires on the Lolo National Forest administered nonwilderness lands totaled 1241 and provide the fire data base used in the study. Table 1 summarizes annual lightning fire occurrence on the Lolo National Forest by land ownership and wilderness designation classes.

The capability of normalizing raw forest fire occurrence data by acreage estimates to produce fire occurrence densities is a recent benefit of the Northern Region's Forest Inventory / Stand Examination procedure, generally known as "Stage 1 inventory". The sample design used, after Stage and Alley (1972), permit statistically-valid forest-wide estimation of acreage distributions among forest cover type, elevation, aspect, slope steepness, and slope position classes. Forest-wide acreage estimates and variances used in the study were computed via the FINSYS subsystem routines TABLES and OUTPUT. The national system is maintained by the USDA Forest Service at the Fort Collins Computer Center.

The FINSYS subsystem stores and manipulates inventory data from 60 land compartments within the Lolo National Forest. The compartments were randomly selected with probability proportional to size for inclusion in the Stage 1 inventory. A total of 583 identifiable stands covering 15,075 acres were sampled within the 60 compartments.

Table 1

Annual Lightning Fire Occurrence by Land Designation

Lolo National Forest

Year	Forest Service	Wilderness Areas	Private Lands	Total Fires
1960	85	3	21	109
1961	174	2	80	256
1962	61	2	29	92
1963	113	3	57	173
1964	29	0	27	56
1965	30	2	21	53
1966	84	0	53	137
1967	83	2	23	108
1968	41	1	14	56
1969	53	0	26	79
1970	101	0	39	140
1971	58	2	16	76
1972	74	0	48	122
1973	174	2	54	230
1974	81	0	37	118
Total	1241	19	545	1805

The acreage estimates from the one-time inventory were assumed to have remained constant (or to have changed insignificantly) between cover type, elevation, aspect, slope steepness, and slope position classes throughout the fifteen year study period. The distribution of forest acres between the three stand management status classes, on the other hand, varied from year to year as a result of forest management activity.

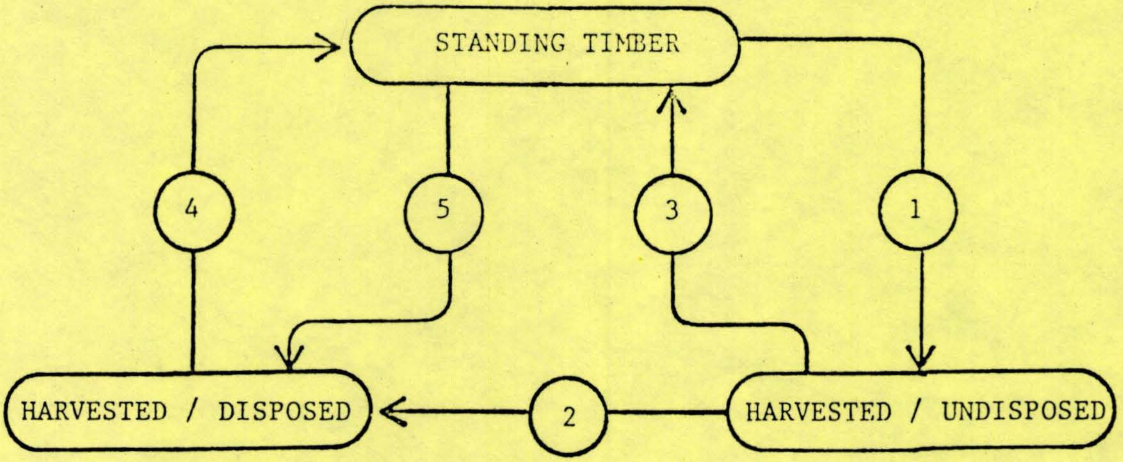
The Northern Region's Stand Examination and Management Status Record (FSH R1 2410-17) was used to determine the yearly distribution of forest acres among the stand management status classes of standing timber, undisposed slash, and disposed (not regenerated) slash sites. The forest management cycle model in Figure 1 was used to exchange acreages between the three classes as a result of five possible management activities as documented by the Stand Examination and Management Status Record; harvests, hazard reduction/site preparation, regeneration following hazard reduction/site preparation, regeneration without previous hazard reduction/site preparation, and wildfire. The Stand Examination and Management Status Record for the Lolo National Forest contained data on 10,753 stands. Table 2 summarizes acreages transferred by the five management activities and by cover type through 1974.

The fire occurrence data from the 5100-29 forms and acreage estimates from the Stage 1 inventory and Stand Examination and Management Status Record were used to compute fire occurrence density and acres burned density statistics presented in the report. All fire statistics are reported as fifteen year means, and fire occurrence and acres burned densities are in units of millions of acres per year. For a more detailed account of the study methods, the reader is referred to "Derivation of Forest Fire Densities on Northern Region National Forests"[3/].

[3/] General technical report in preparation. USDA For. Serv., Intermtn. F&R Experiment Station, Ogden, Utah

FIGURE 1

FOREST MANAGEMENT STATUS CYCLE



VECTOR	DESCRIPTION
1	Harvest -- clearcut, shelterwood, seed tree, overstory removal, rehabilitation, select, salvage, and intermediate cuts
2	Hazard Reduction or Site Preparation -- prescribed burning, lopping, jackpot burning, dozer piling and terracing, hand piling, trampling, herbicide spraying, spraying and burning, rolling chopper, machine scarifying, furrowing, and discing, and wildfire
3	Regeneration without Previous Hazard Reduction or Site Preparation
4	Regeneration Following Hazard Reduction or Site Preparation
5	Wildfire -- severe and large enough to be coded as a "harvest or other drain" on the Stand Examination and Management Status record

Figure 2

Methodology for Computing Forest Fire Densities

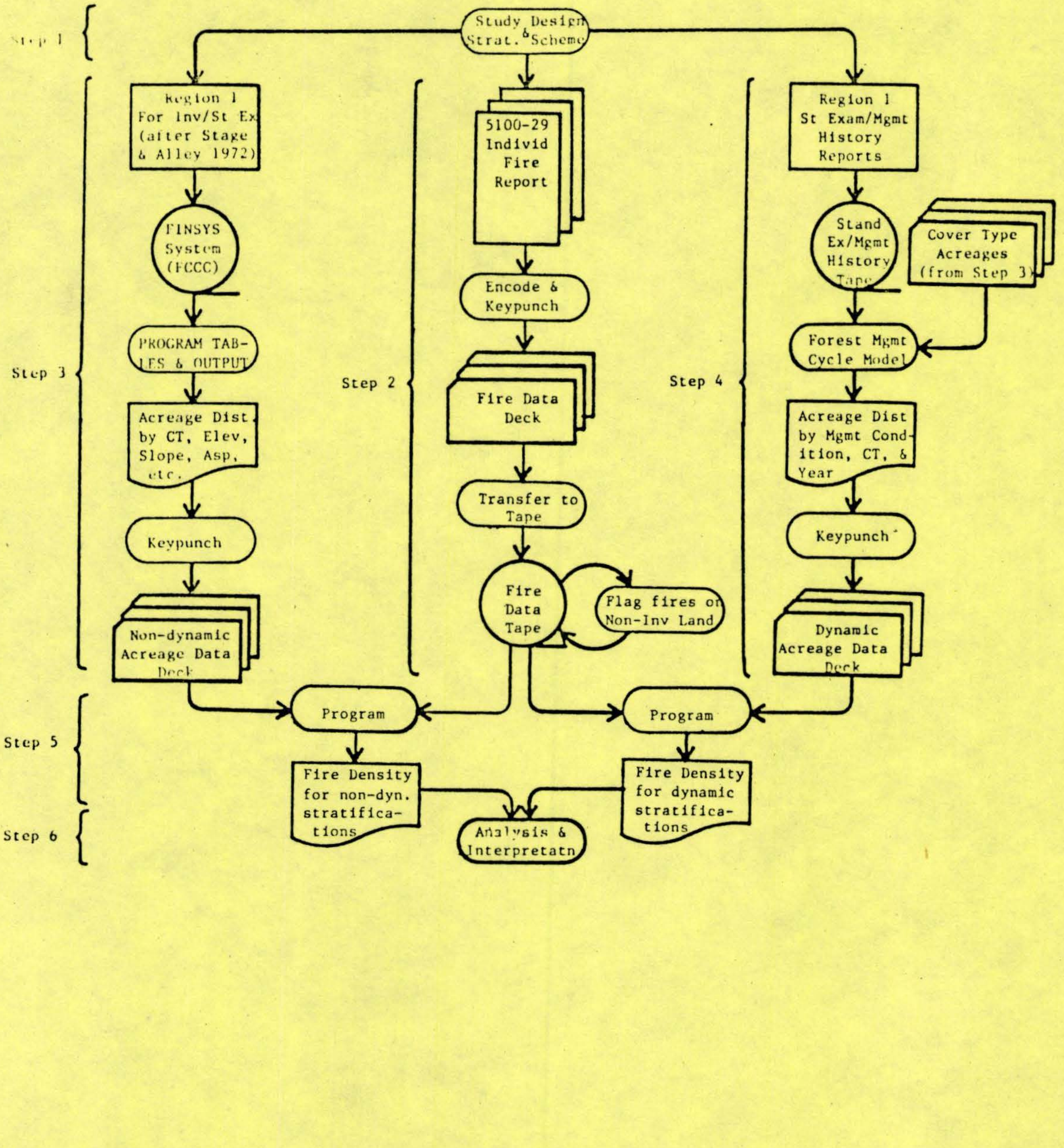

Step 1
Study Design & Strat. Scheme
Step 3
Region 1 For Inv/St Ex (after Stage & Alley 1972)
FINSYS System (FCCC)
PROGRAM TABLES & OUTPUT
Acreage Dist. by CT, Elev, Slope, Asp, etc.
Keypunch
Non-dynamic Acreage Data Deck
Step 2
5100-29 Individ Fire Report
Encode & Keypunch
Fire Data Deck
Transfer to Tape
Fire Data Tape
Flag fires on Non-Inv Land
Step 4
Region 1 St Exam/Mgmt History Reports
Stand Ex/Mgmt History Tape
Cover Type Acreages (from Step 3)
Forest Mgmt Cycle Model
Acreage Dist by Mgmt Condition, CT, & Year
Keypunch
Dynamic Acreage Data Deck
Step 5
Program
Program
Fire Density for non-dyn. stratifications
Fire Density for dynamic stratifications
Step 6
Analysis & Interpretatn

Table 2

Summary of Management Activity by Cover Type through 1974

Lolo National Forest

Forest Cover Type	Harvests	Hazard Reduction Site Preparation	Regeneration wo. Site Preparation	Regeneration with Site Preparation	Wildfire
Ponderosa Pine	35486	17045	4593	9455	870
Douglas-fir	97092	31424	5670	17932	788
Lodgepole Pine	18235	6101	711	3014	343
Engelmann Spruce	7783	4740	1138	3561	435
Western Larch	27255	13882	2858	9267	131
Grand Fir	5328	859	361	454	0
Cedar - Hemlock	1080	210	27	94	0
Subalpine Types	11756	4294	1301	2918	102
Western White Pine	178	35	0	0	0
Other / Unknown	19975	4241	60	59	170
Total on Record	224168	82831	16719	46754	2839

Study Results

Forest Cover Type Lightning Fire Density

Ten forest cover type classes were recognized based upon species plurality as per the Stage 1 inventory procedure. The canopy types within each class are:

1) ponderosa pine : ponderosa pine
2) Douglas-fir : Douglas-fir
3) lodgepole pine : lodgepole pine
4) Engelmann spruce : Engelmann spruce
5) western larch : larch - Douglas-fir
   larch - ponderosa pine - Douglas-fir
6) grand fir : grand fir - larch - Douglas-fir
7) cedar - hemlock : western red cedar
   western hemlock
8) subalpine types : subalpine fir - Engelmann spruce
   mountain hemlock - subalpine fir
   subalpine larch - subalpine fir - lodgepole pine - whitebark pine
   whitebark pine - limber pine
9) other stockable cover types : western white pine
10) nonstockable : grass - shrub
   Pacific yew - juniper
   noncommercial forest - nonforest

No hardwood cover types were inventoried on the Lolo National Forest.

Ponderosa pine had the highest lightning fire occurrence density of all cover type classes, 476.5 fires per million acres per year (Table 3), followed by western larch (201.3) and spruce (164.9) cover types. Douglas-fir, lodgepole pine, and subalpine types had the lowest occurrence densities, 26.9, 26.0, and 19.3 fires/mm acres/year, respectively. All stockable forest lands aver-

Table 3

Lolo National Forest

Lightning Fire Density by Forest Cover Type Class

1960 - 1974

	Forest Acres		Fire Occurrence		Occurrence Density		Acres Burned		Acres Burned Density		Acres/Fire	
Forest Cover Type	Est Total	St Dev	No/Yr	St Dv	N/mmAc/Yr	St Dv	No/Yr	St Dv	Ac/mmAc/Y	St Dv	Mean	Median
Ponderosa Pine	52041.5	12417.7	24.8	11.8	476.5	227.6	64.9	187.7	1247.0	3606.2	2.6	0.2
Douglas-fir	708624.7	45652.8	19.0	11.9	26.8	16.8	21.4	36.0	30.3	50.8	1.1	0.2
Lodgepole Pine	492904.4	31427.4	12.8	10.8	26.0	21.9	213.0	795.5	432.2	1613.8	16.6	0.2
Engelmann Spruce	18599.0	6538.7	3.1	3.5	164.9	186.8	0.6	0.7	34.1	39.8	0.2	0.2
Western Larch	40742.8	11224.9	8.2	5.7	201.3	139.8	2.8	3.3	69.2	80.6	0.3	0.2
Grand Fir	94460.3	22993.4	3.0	1.9	31.8	20.4	0.9	0.9	9.2	9.9	0.3	0.2
Cedar - Hemlock	21272.7	8605.0	0.8	0.7	37.6	31.8	0.6	1.3	26.0	59.0	0.7	0.2
Subalpine Types	383804.0	40087.2	7.4	6.3	19.3	16.5	22.7	53.7	59.1	140.0	3.1	0.2
Other Stockable	2196.5	1502.4	0.4	0.8	182.1	377.0	0.2	0.8	112.3	373.4	0.6	0.2
Total Stockable	1814645.0	16.4	79.5	42.0	43.8	23.1	327.2	812.9	180.3	448.0	4.1	0.2
Nonstockable	163727.8	4.3	3.3	2.7	20.0	16.6	1.1	1.5	6.6	9.1	0.3	0.2
Inventory Total	1978372.8	16.9	82.7	44.2	41.8	22.4	328.3	813.0	165.9	410.9	4.0	0.2

aged 43.8 fires/mm acres/year, while nonstockable sites averaged 20.0 fires per million acres annually. Figure 3 ranks the cover types by fire occurrence and fire ocurrence density.

Ponderosa pine also had the highest acres burned density, 1247 acres burned per million acres per year. Engelmann spruce was next highest with 432 acres burned/mm acres/year. Spruce cover types also had the largest mean fire size, 16.1 acres per fire. Subalpine types were second at 3.1 acres/fire, and ponderosa pine third with 2.6 acres per fire. Mean fire size for all other cover types was under one acre. The median fire size was 0.2 for all cover type classes. Figure 4 ranks cover types by acres burned and acres burned density, and Figure 5 displays cover type acreage distributions.

Stand Management Status Lightning Fire Density

The most flammable stand management condition on the Lolo National Forest was disposed slash sites (Table 4). Disposed slash fire occurrence density was 556 fire per million acres per year, or ten times that of undisposed slash sites. Standing timber fire occurrence density was 41 fires/mm acres/year. Stand flammability appears to increase dramatically as the site is converted from standing timber to undisposed slash to disposed slash.

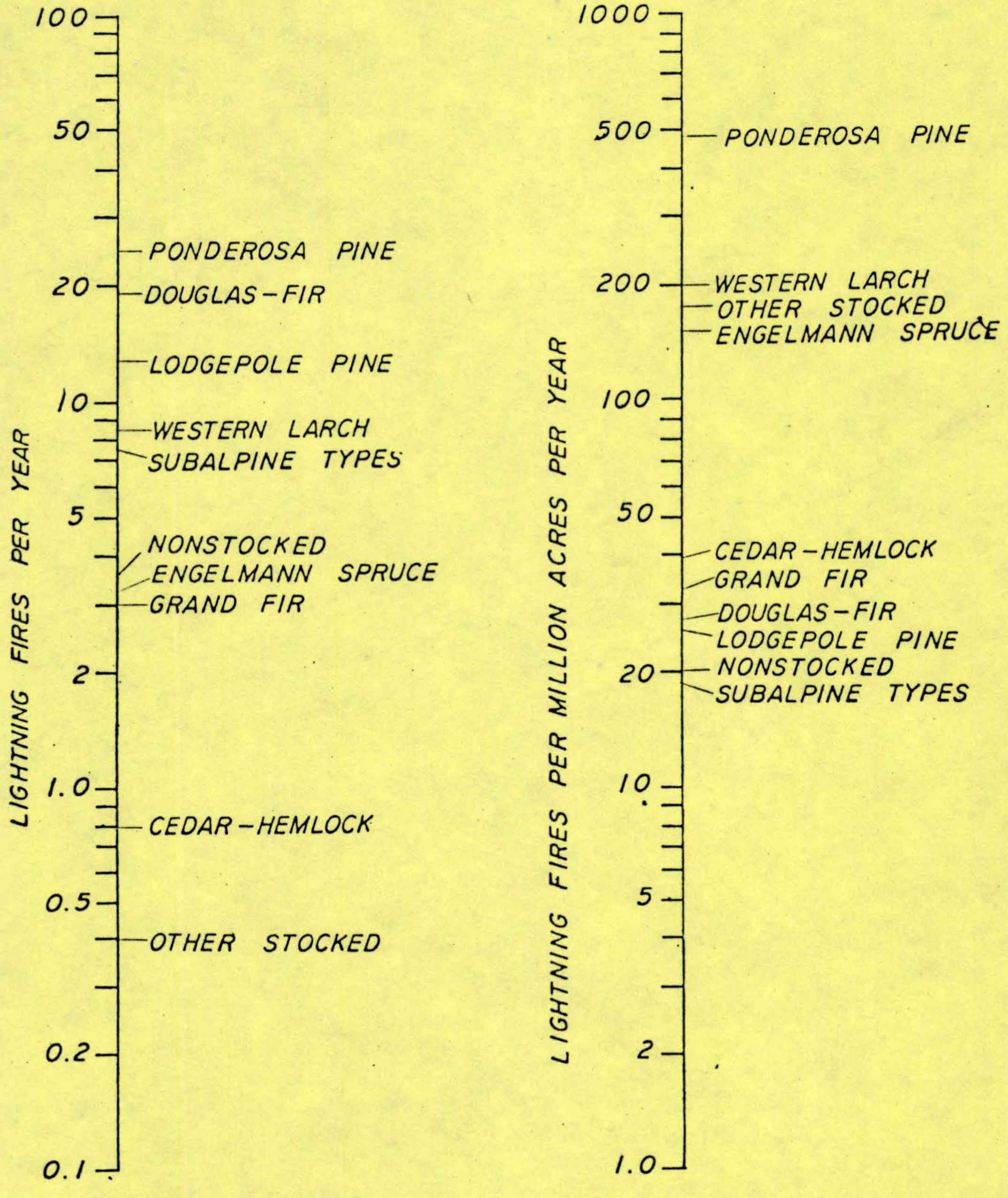
Disposed and undisposed slash sites had similar acres burned densities of 597 and 507 acres burned/mm acres/year, respectively. An order of magnitude difference in mean fire size was found for the two cutover conditions, however; 16.6 acres/fire in undisposed slash, and 0.8 acres/fire on disposed sites. Mean fire size for standing timber was intermediate at 3.8 acres.

The data suggest traditional hazard reduction and site preparation methods may actually increase the probability of a lightning strike starting a reportable fire. The mechanism involved may be the conversion from heavy,

Figure 3

LOLO NATIONAL FOREST

LIGHTNING FIRE OCCURRENCE AND OCCURRENCE DENSITY
BY FOREST COVER TYPE
1960 — 1974

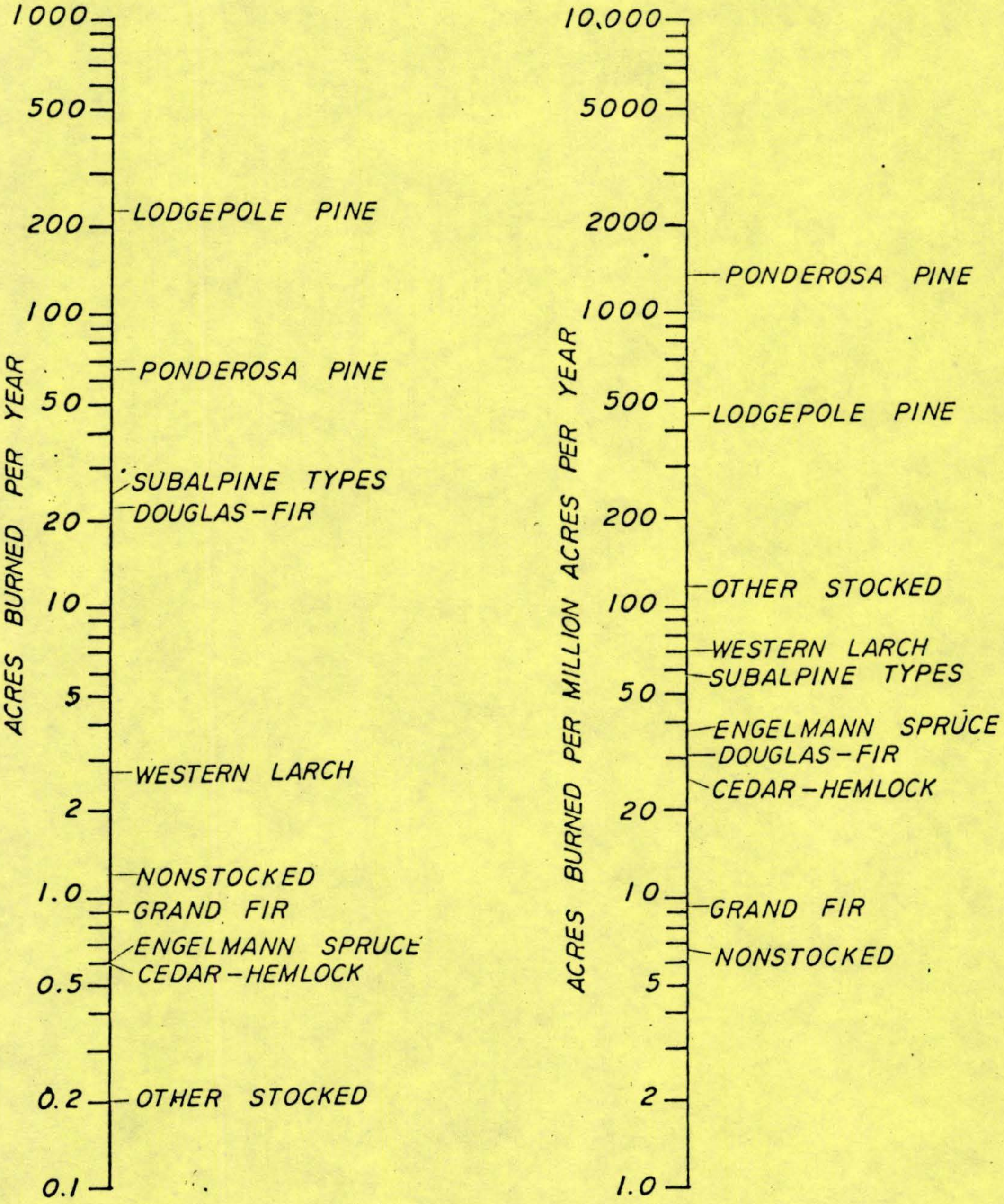


SEM 1979
MISSOULA, MT

Figure 4

LOLO NATIONAL FOREST

LIGHTNING FIRE ACRES BURNED AND ACRES BURNED DENSITY
BY FOREST COVER TYPE
1960 — 1974



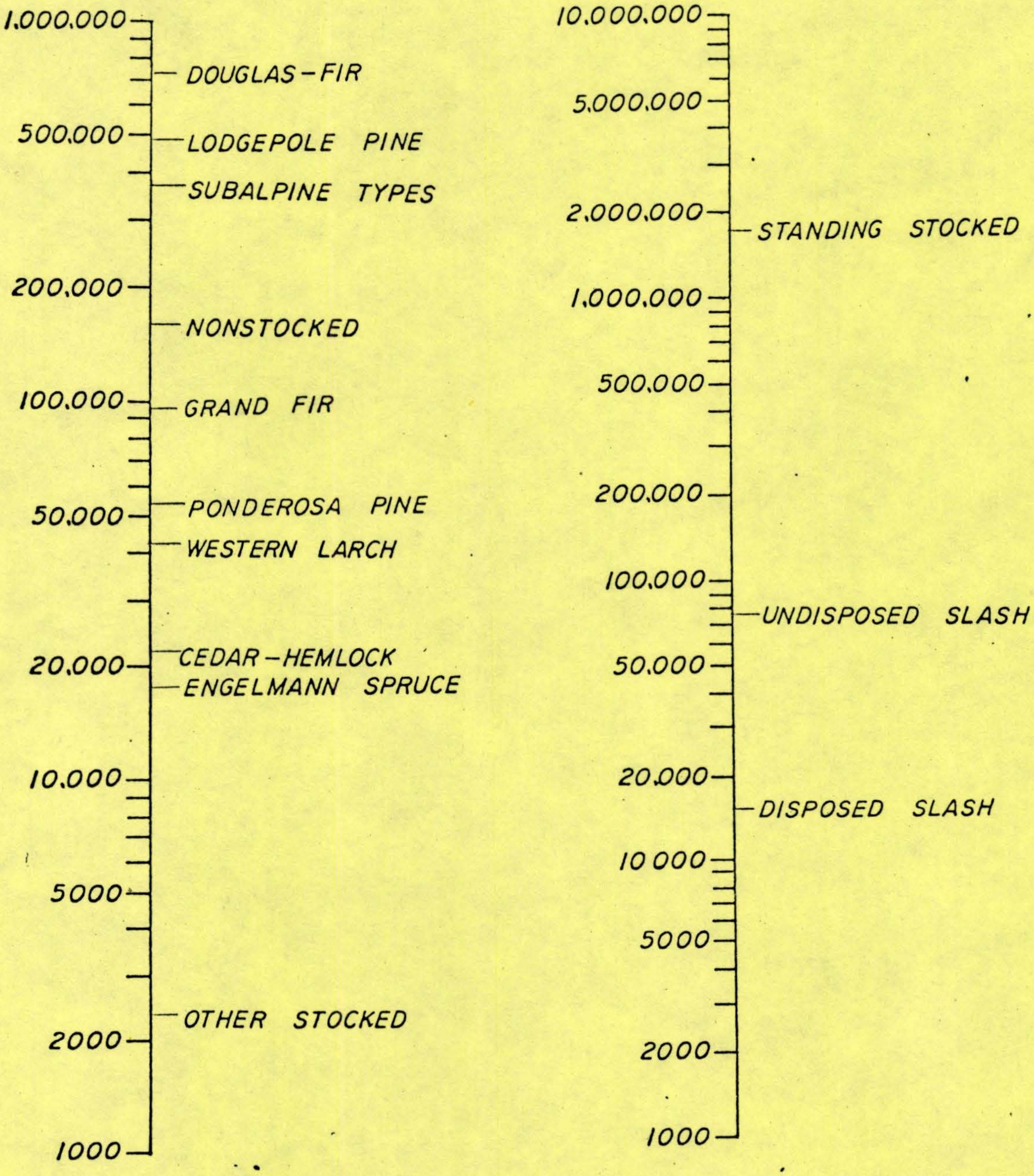
SEM 1978

FIGURE 5

FOREST COVER TYPE AND STAND MANAGEMENT STATUS ACREAGES

LOLO NATIONAL FOREST

1960 – 1974 MEANS



SEM 1979
MISSOULA, MT

Table 4

Lolo National Forest

Lightning Fire Density by Stand Management Status Class

1960 - 1974

	Forest Acres		Fire Occurrence		Occurrence Density		Acres Burned		Acres Burned Density		Acres/Fire	
Stand Mgmt. Status	Est Total*	St Dev	No/Yr	St Dv	N/mmAc/Yr	St Dv	No/Yr	St Dv	Ac/mmAc/Y	St Dv	Mean	Median
Standing Timber	1719748.2	45822.6	70.0	37.5	40.7	21.8	262.9	808.2	147.9	451.9	3.8	0.2
Undisposed Slash	77975.1	36471.8	3.6	3.5	55.5	60.0	59.7	188.3	507.0	1527.4	16.3	0.2
Disposed Slash	16921.7	10056.6	5.7	4.4	556.4	748.2	4.6	11.6	597.0	1693.9	0.8	0.2
Stockable Total	1814645.0	16.4	79.3	42.1	43.7	23.2	327.1	812.9	180.3	448.0	4.1	0.2
Nonstockable	163727.8	4.3	3.3	2.7	20.0	16.6	1.1	1.5	6.6	9.1	0.3	0.2
Inventory Total	1978372.8	16.9	82.7	44.3	41.7	22.4	328.2	813.0	165.9	410.9	4.0	0.2

* Average acreage in status class from 1960 through 1974.

compacted slash fuels which are relatively difficult to ignite, to light, flammable grasses and annuals. Such fuel conversion may also account for differences in mean fire size between disposed and undisposed sites. The same heavy, compacted slash fuels which are difficult to ignite (especially under moist conditions) offer considerable resistance to control once a propagating fire front has become established. Light grass fuels, while easier to ignite under moist conditions (and which dry out faster after a wetting cycle) are also easier to contain.

The question of which condition is more costly to manage -- undisposed sites with a low fire occurrence density but large fire size, or disposed sites with a high fire occurrence density but small fire size -- can only be answered by examining historical suppression costs of fires within the two stand management status classes.

Table 5 further breaks down lightning fire occurrence density into cover type and stand management status classes. The pattern of increasing fire occurrence density from standing timber to undisposed slash to disposed slash is exhibited by all cover types.

Figure 6 ranks stand management status classes by fire occurrence and occurrence density, and Figure 7 ranks the classes by acres burned and acres burned density. Stand management status class acreages are shown in Figure 5.

Elevation Band Lightning Fire Density

The lightning fire regime on the Lolo National Forest appears to change little with increasing elevation (Table 6). The highest lightning fire occurrence density of 65.1 fires/mm acres/year is found at elevations under 4000 feet. The second highest occurrence density of 58.1 fires/mm acres/year occurs above 7000 feet. Mid-elevation fire densities ranged from 33 to 45 fires/mm acres/year. Little variability was found in acres burned, acres burned

Table 5

Lolo National Forest

Lightning Fire Density by Stand Cover Type & Management Status Class

Cover Type	Standing Timber	Undisposed Slash	Disposed Slash	Cover Type Total
Ponderosa Pine	20.1	1.3	3.3	24.7
	558.2	117.0	1565.2	475.3
	13.8	49.7	1.5	64.9
	380.0	3267.5	834.8	1246.7
Douglas-fir	16.8	1.1	1.1	18.9
	25.3	32.2	707.4	26.7
	9.6	9.2	2.7	21.4
	14.2	186.0	2636.1	30.2
Lodgepole Pine	12.1	0.4	0.3	12.8
	24.9	94.3	228.5	26.0
	212.6	0.2	0.3	213.0
	432.8	30.0	134.6	432.2
Engelmann Spruce	2.9	0.0	0.1	3.1
	182.5	0.0	93.6	164.9
	0.6	0.0	0.0	0.6
	37.7	0.0	18.7	34.1
Western Larch	7.0	0.4	0.8	8.2
	218.6	82.7	629.6	201.3
	2.2	0.5	0.1	2.8
	68.6	85.7	121.8	69.2
Grand Fir	2.7	0.2	0.1	3.0
	29.6	56.6	1754.4	31.8
	0.8	0.0	0.0	0.9
	8.9	9.7	350.9	9.2
Cedar - Hemlock	0.8	0.0	0.0	0.8
	38.4	0.0	0.0	37.6
	0.6	0.0	0.0	0.6
	26.4	0.0	0.0	26.0
Subalpine Types	7.2	0.2	0.0	7.4
	19.0	116.1	0.0	19.3
	22.6	0.0	0.0	22.7
	59.5	23.2	0.0	59.1
Other Stockable Cover Types	0.3	0.0	0.0	0.3
	0.0	0.0	0.0	151.8
	0.2	0.0	0.0	0.2
	0.0	0.0	0.0	109.3
Stockable Lands Total	70.0	3.6	5.7	79.3
	40.7	55.5	556.4	43.7
	262.9	59.7	4.6	327.1
	147.9	507.0	597.0	180.3

Table Statistics : 1960-1974 Means

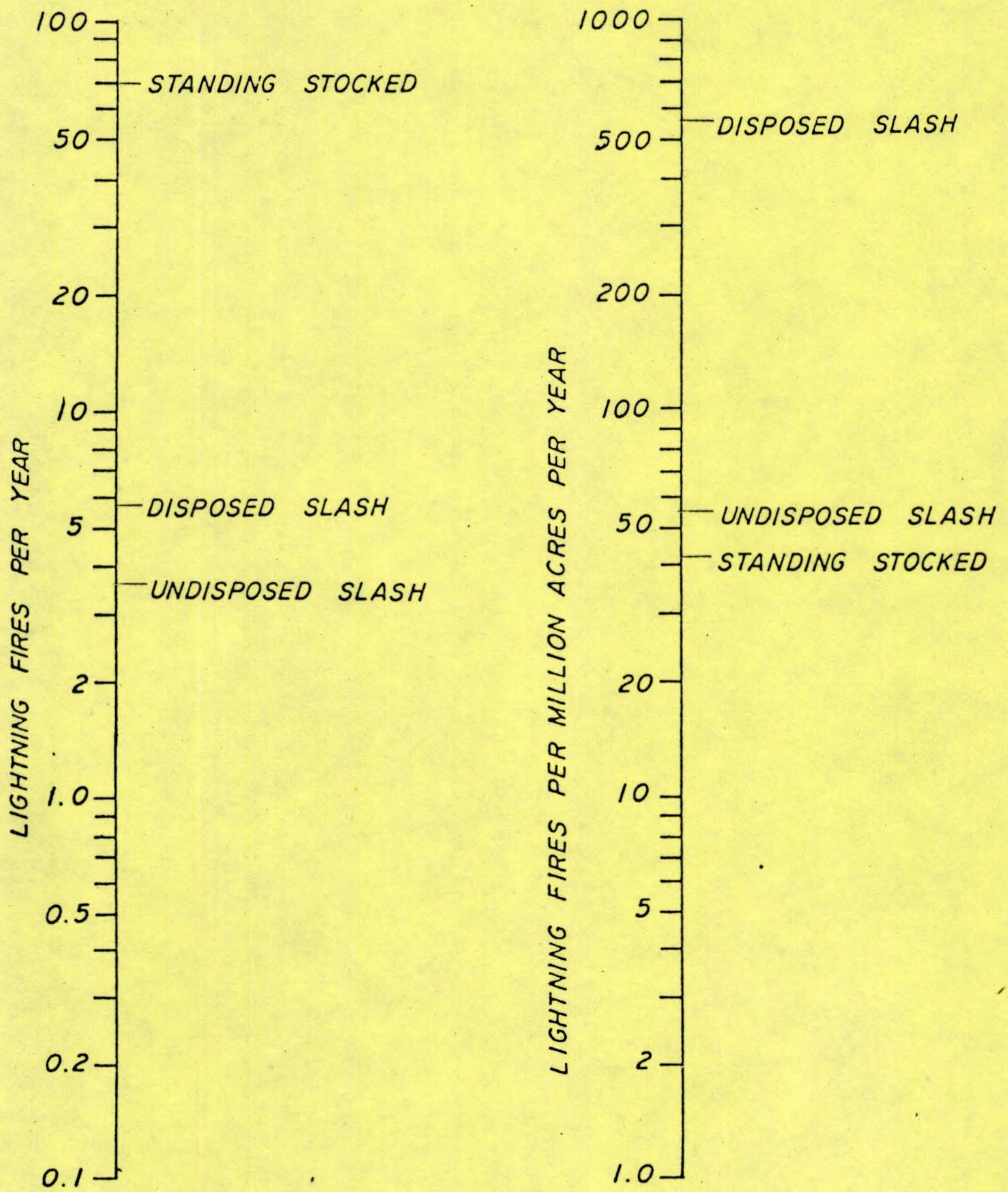
Fire Frequency (Fires/Year)
Frequency Density (Fires/mm Ac/Yr)
Acres Burned (Acres Burned/Yr)
Acres Burned Density (Acres Burned/mm Ac/Yr)

Figure 6

LOLO NATIONAL FOREST

LIGHTNING FIRE OCCURRENCE AND OCCURRENCE DENSITY
BY STAND MANAGEMENT STATUS

1960 — 1974



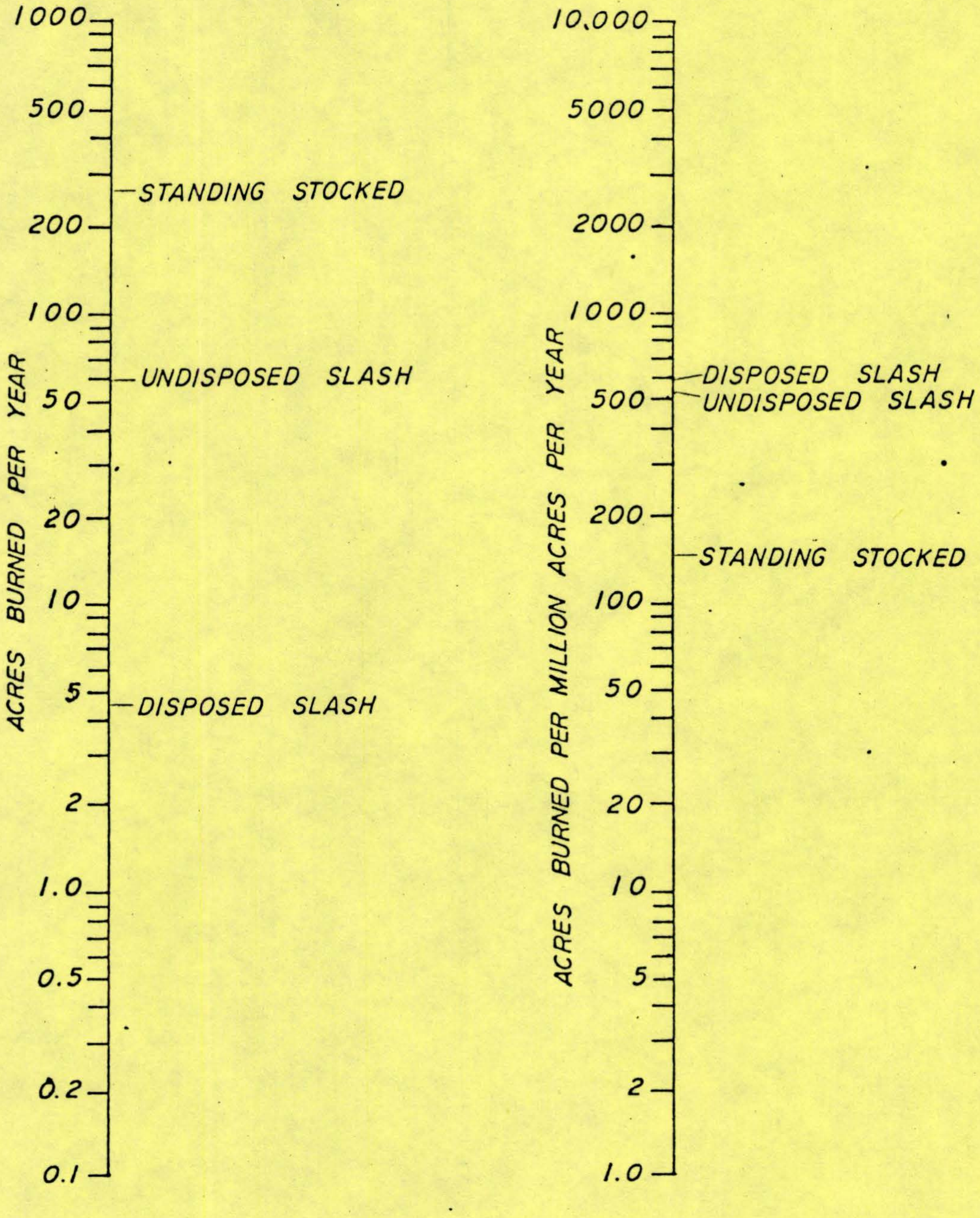
SEM 1979
MISSOULA, MT

Figure 7

LOLO NATIONAL FOREST

LIGHTNING FIRE ACRES BURNED AND ACRES BURNED DENSITY BY STAND MANAGEMENT STATUS

1960 — 1974



SEM 1978

Table 6

Lolo National Forest

Lightning Fire Density by Elevation Band

1960 - 1974

	Forest Acres		Fire Occurrence		Occurrence Density		Acres Burned		Acres Burned Density		Acres/Fire	
Elevation Band	Est Total	St Dev	No/Yr	St Dv	N/mmAc/Yr	St Dv	No/Yr	St Dv	Ac/mmAc/Y	St Dv	Mean	Median
Under 4000 Feet	164986.0	32843.8	10.7	5.6	65.1	34.0	5.5	4.8	33.3	28.9	0.5	0.2
4000 - 4999 Feet	552111.0	43141.2	23.3	14.0	42.3	25.3	276.2	802.1	500.3	1452.8	11.8	0.2
5000 - 5999 Feet	803792.9	48280.7	26.9	17.0	33.4	21.1	28.8	66.7	35.8	83.0	1.1	0.2
6000 - 6999 Feet	371379.1	41828.7	16.7	15.7	44.9	42.3	16.1	23.8	43.3	64.0	1.0	0.2
7000 Feet Plus	86103.9	21774.9	5.0	3.4	58.1	40.0	1.7	1.6	19.3	18.1	0.3	0.2
Inventory Total	1978372.9	16.4	82.7	44.3	41.7	22.4	328.2	813.0	165.9	410.9	4.0	0.2

densities, and mean and median fire size statistics for the elevation bands, with the exception of a few large fires which occurred in the 4000 to 4999 foot interval.

Aspect Class Lightning Fire Density

Table 7 shows lightning fire statistics for eight aspect and two slope position classes on the Lolo National Forest, and condenses the aspects into four classes corresponding to the cardinal compass points. South-southwest aspects on the Lolo National Forest had the highest values of all aspect classes for fire occurrence density (68 fires/mm acres/year), acres burned density (624 acres burned/mm acres/year), and mean fire size (9.2 acres per fire). West-northwest aspects had the lowest fire statistics. After south-southwest aspects, ridgetops and level sites had the highest fire occurrence densities of 51 and 44 fires/mm acres/year, respectively.

Slope Steepness Class Lightning Fire Density

Tables 8a and 8b present lightning fire statistics for two combinations of slope steepness classes. Fire occurrence density started out high at 149 fires/mm acres/year for 0% to 15% slopes, steadily decreased to 19 fires/mm acres/year around 45% slope steepness, then increased again to 598 fires per million acres annually on slopes greater than 75%. Slopes between 16% and 35% had the highest acres burned density (401 acres burned/mm acres/year) and mean fire size (10.5 acres/fire).

Table 7

Lolo National Forest

Lightning Fire Density by Aspect Class

1960 - 1974

	Forest Acres		Fire Occurrence		Occurrence Density		Acres Burned		Acres Burned Density		Acres/Fire	
Aspect Class	Est Total	St Dev	No/Yr	St Dv	N/mmAc/Yr	St Dv	No/Yr	St Dv	Ac/mmAc/Y	St Dv	Mean	Median
North	232160.6	30743.9	11.0	7.3	47.4	31.5	3.1	2.4	13.2	10.5	0.3	0.2
Northeast	217112.3	38681.6	7.5	5.1	34.7	23.6	15.2	51.9	70.1	238.8	2.0	0.2
East	235557.3	33264.1	9.3	7.4	39.3	31.3	5.7	10.7	24.2	45.5	0.6	0.2
Southeast	300278.6	35900.3	12.3	6.7	40.9	22.2	66.6	187.4	221.9	624.0	5.4	0.2
South	222696.4	24812.2	15.3	9.0	68.6	40.5	17.9	26.5	80.3	119.0	1.2	0.2
Southwest	145055.1	25265.6	9.6	4.6	66.2	31.9	211.5	797.3	1457.7	5496.8	22.0	0.2
West	188551.3	26920.2	8.6	4.5	45.6	24.1	5.5	6.0	29.1	31.9	0.6	0.2
Northwest	351310.3	44430.7	5.1	3.3	14.6	9.4	1.8	1.6	5.3	4.6	0.4	0.2
Level	53176.5	13127.7	2.3	2.1	43.9	40.0	0.6	0.8	10.9	14.4	0.2	0.2
Ridgetops	32474.3	8247.4	1.7	1.9	51.3	57.8	0.4	0.4	11.1	12.5	0.2	0.2
Inventory Total	1978372.8	16.4	82.7	44.3	41.7	22.4	328.3	813.0	165.9	410.9	4.0	0.2
North - Northeast	449273.0	47789.9	18.5	11.7	41.3	25.9	18.3	53.4	40.7	118.8	1.0	0.2
East - Southeast	535836.0	48082.9	21.5	13.3	40.2	24.8	72.3	186.2	135.0	347.4	3.4	0.2
South - Southwest	367751.6	34736.6	24.9	12.8	67.8	34.8	229.4	796.8	623.7	2166.6	9.2	0.2
West - Northwest	539861.6	50354.7	13.7	6.9	25.4	12.7	7.3	6.3	13.6	11.7	0.5	0.2

Table 8a

Lolo National Forest

Lightning Fire Density by Slope Steepness Class

1960 - 1974

	Forest Acres		Fire Occurrence		Occurrence Density		Acres Burned		Acres Burned Density		Acres/Fire	
Slope Steepness	Est Total	St Dev	No/Yr	St Dv	N/mmAc/Yr	St Dv	No/Yr	St Dv	Ac/mmAc/Y	St Dv	Mean	Median
0 - 15%	105406.5	19838.2	15.7	11.8	148.6	112.4	4.0	2.6	38.1	24.9	0.3	0.2
16 - 25%	172056.3	29606.1	9.2	7.6	53.5	44.4	4.1	5.9	23.8	34.1	0.4	0.2
26 - 35%	377433.9	39257.8	11.7	6.9	31.1	18.2	216.3	793.6	573.1	2102.6	18.4	0.2
36 - 45%	439008.7	39893.7	10.5	5.4	23.8	12.3	3.7	3.1	8.5	7.0	0.4	0.2
46 - 55%	482072.5	39521.0	9.3	5.0	19.2	10.4	61.4	188.8	127.4	391.7	6.6	0.2
56 - 65%	272517.1	30790.2	11.1	6.7	40.9	24.7	11.6	24.3	42.6	89.0	1.0	0.2
66 - 75%	116272.6	27226.9	7.1	5.7	61.4	49.0	19.6	54.0	168.5	464.6	2.7	0.2
76 - 85%	11023.3	6461.2	3.4	2.7	308.4	244.4	3.9	10.2	353.2	923.7	1.1	0.2
Over 85%	2582.0	2222.0	4.7	4.6	1833.2	1777.6	3.6	4.5	1407.2	1741.7	0.8	0.2
Inventory Total	1978372.8	16.7	82.7	44.3	41.7	22.4	328.3	813.0	165.9	410.9	4.0	0.2

Table 8b

Lolo National Forest

Lightning Fire Density by Slope Steepness Class

1960 - 1974

	Forest Acres		Fire Occurrence		Occurrence Density		Acres Burned		Acres Burned Density		Acres/Fire	
Slope Steepness	Est Total	St Dev	No/Yr	St Dv	N/mmAc/Yr	St Dv	No/Yr	St Dv	Ac/mmAc/Y	St Dv	Mean	Median
0 - 15%	105406.5	19838.2	15.7	11.8	148.6	112.4	4.0	2.6	38.1	24.9	0.3	0.2
16 - 35%	549490.2	47321.2	20.9	13.8	38.1	25.1	220.4	792.8	401.1	1442.7	10.5	0.2
36 - 55%	921081.1	51319.1	19.7	8.1	21.4	8.8	65.1	188.5	70.7	204.6	3.3	0.2
56 - 75%	388789.7	38359.3	18.3	11.6	47.0	29.8	31.2	77.6	80.2	199.6	1.7	0.2
Over 75%	13605.3	6832.6	8.1	6.8	597,8	496.9	7.5	10.1	553.2	741.5	0.9	0.2
Inventory Total	1978372.8	17.7	82.7	44.2	41.8	22.4	328.3	813.0	165.9	410.9	4.0	0.2

Literature Cited

Barrows, Jack S. 1951. Forest fires in the northern Rocky Mountains. USDA Forest Service Northern Rocky Mountain Forest and Range Experiment Station Paper No. 28. 251 p.

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